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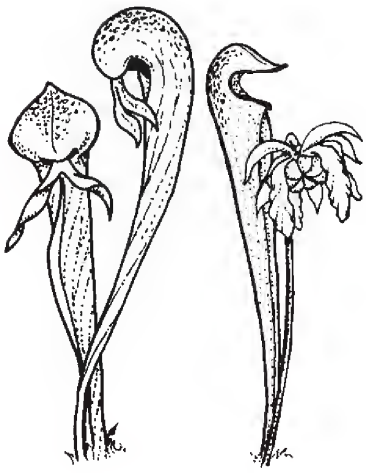

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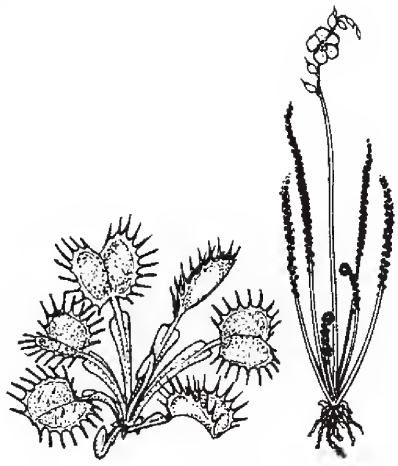

Front Cover: The Australian Pimpernel Sundew (*Drosera glanduligera*) in Western Australia. Photo by Barry Rice. Article on page 101.

Back Cover: A *Genlisea* bouquet of *G. pygmaea* (yellow), *G. hispidula* (lilac), *G. violacea* (purplish). Photo by Barry Rice. Article on page 114.

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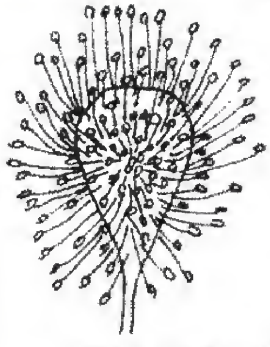

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The 8th ICPS Conference in Leiden

Marcel van den Broek • marcel@carnivorousplants.org

Judging from the comments of those who visited and those who organized it, the 8th Conference was a big success.

First of all there were the great lectures from a big line up of speakers. I will not single out any of them because basically all lectures were great in their context. They provided an interesting mixture of species, cultivation, research, regulations, and fieldwork for the people attending.

Second, from an education and commercial point of view, 8500 people visited the accompanying exhibition in the botanical garden. The special kids items like giant carnivorous plants to play with, a kids lecture, and a special kiddy tour with nice prizes if you filled in the questionnaire also got lots of attention. This left the botanical garden a satisfied host to the event.

Most importantly, a good time was had by all.

An important part of the Conference was to have a discussion on a specific issue with a panel and the audience. The issue chosen was *ex-situ* conservation, which led to a refinement of the discussion to rules and regulations. While the discussion did not reach a nice rounded-out conclusion, there were some interesting points made and some openings offered. I'll try to summarize them.

While the discussion started out on CITES, the Convention on International Trade in Endangered Species of wild fauna and flora, it was soon clear that the problems run much wider.

First of all, CITES deals only with trade. It came from an IUCN resolution in 1975 and put in place a basic set of rules for international trade. This brings us to the first two problems. First, it deals with trade and it is not "invented" as a conservation tool. Second, it establishes a basic set of rules. On this basis, permits and certificates can be given. However, every signatory state is free to add its own extra rules to the CITES set of rules. Consequently, the set of rules are no longer the same in every country.

The next problem turns out to be not CITES at all, but the CBD (Convention on Biological Diversity). In 1993, CBD was set up as guidelines to protect all biological diversity. Main terms are sustainability and share of the benefits by the original owners of said biodiversity. The problems here come from the fact that it gives guidelines and not set rules so there is much difference in every country. Go to the core of the problem and basically the country where the plant material originally came from has to agree that you are allowed to have it. Cross to CITES: No permit if you can't prove the original stock is legal.

A final problem that came to the table is the information needed to update the lists of protected species CITES uses. The problem lies in the fieldworkers. Are they willing to provide the necessary data to update the lists? The problem here is that most fieldwork is at least partly funded by commercial interests. Nothing new about that, it goes back to Victorian times and before. Just ask for instance the Veitch family. However, while most commercial nurseries are very willing to protect the plants they truly love, there is some understandable reluctance to provide data that can make a species much more difficult to trade.

So, no solutions at all? Not quite. There is for instance a genuine opening in the CITES process. The IUCN Species Survival Commission that makes the CITES rules works with specialists groups for advice. There used to be such a group for carnivorous plants and there is a very real option offered to reactivate this group.

On the closing of the discussion, the offer was made to create a small discussion group to consider options like reactivating the carnivorous plants specialist group or at least prepare points of discussion to continue efforts to improve on the problems people are having with the mostly unintended effects of CITES and CBD. This might be a basis for instance to have a continued discussion on the next ICPS Conference.

As I offered to bring those who are interested in taking part in this discussion in contact with each other, you can contact me at marcel@carnivorousplants.org.

Snap-tentacles and runway lights: Summary of comparative examination of *Drosera* tentacles

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Keywords: Droseraceae, *Drosera glanduligera*, *D. hartmeyerorum*, lens-tentacles, snap-tentacles, systematics

Introduction

Many CP-books describe the trapping mechanism of *Drosera* generally as leaves with sticky stalked glands, which are able to bend towards the caught prey. However, the traps are actually not that simple. Even as early as 1875, Charles Darwin, in his book "The Insectivorous Plants" (Darwin 1888) and a few later scientific publications mention two different tentacle structures for *Drosera rotundifolia*. Since 2003, we have published information showing the morphology of *Drosera* tentacles is actually even more sophisticated (Hartmeyer 2003, 2004; Hartmeyer & Hartmeyer 2005, 2006a-d, 2008a, b). As of December 2009, we have investigated more than 100 world-wide distributed species and varieties. From this work, we concluded that the term "stalked glands", often used as synonym for all *Drosera* tentacles, must be considered as much too simplifying and even incorrect in many cases. A good example is the Australian Pimpernel Sundew (*D. glanduligera* Lehm.), published by Lehman in 1844 (see Front Cover). In the early 1970s, a nine-year-old young boy named Richard Davion found that the elongated marginal tentacles of *D. glanduligera*, which was growing close to his property in Adelaide, moved within fractions of a second. But like Lehman's description, the carnivorous plant literature (*i.e.* Erickson 1968 and Lowrie 1989) described the plant as a common sundew, and so for many years nobody believed this young Australian.

In 2003, Davion mailed his private video-shots of the phenomenon, including some seeds, asking us to confirm his observation. Equipped with camcorder and USB-microscope, we examined the minute, always hungry and absolutely nasty to cultivate sundew, during two winter seasons. By 2005, we had collected enough material to fully confirm Davion's observations and to publish even more amazing features, such as the unique ontogenetic development (Hartmeyer & Hartmeyer 2005). We were also able to produce our Hunting Veggies® videos and to describe the conditions necessary to cultivate that "diva", which is considered by some experts as a kind of missing link between the sticky traps and the snap-traps in family Droseraceae. To our surprise, merging this awareness with our continuing experiments with other "snap-tentacle sundews", produced a clear view of the relations between, and even the phylogeny of, the Droseraceae based on their easily recognized different trap structures. One more result was the understanding of the morphology and function of the odd yellow lens-tentacles on the leaves and bracts of *D. hartmeyerorum* Schlauer (Schlauer 2001). So now, four years after our DVD "*Drosera*: Snap-Tentacles and Runway Lights" (Hartmeyer & Hartmeyer 2006) was shown at the ICPS conference 2006 in Frostburg—which documents this work until 2005—, it's a pleasure for us to now provide a detailed summary of our comparative examinations on *Drosera* tentacles for CPN.

Drosera tentacles in literature since 1875

Talking about the ability of some species of carnivorous plants to catch prey with active moving traps has been of high interest for a long time. Therefore, it is actually amazing that the easily observed fast movement, and the differing morphology, of marginal *Drosera* tentacles, especially with several eye-catching pygmy *Drosera* (section *Bryastrum, Lamprolepis*), has been badly neglected, or simply ignored—even with the publication of new species in recent literature—at least until our publication in early 2005 on a sundew possessing a true snap-mechanism (Hartmeyer & Hartmeyer 2005). The scientific book "The Carnivorous Plants" (Juniper *et al.* 1989) mentions that several species exist which develop rapid moving, glue-less marginal tentacles (*e.g. D. burmannii*), putting them into a context of evolution from *Drosera* tentacles to the snap trap of *Dionaea*. But as mentioned, even the old authors knew about the non-glandular tentacles of *D. rotundifolia*. Beside Charles Darwin's first remarks in "Insectivorous Plants" (Darwin 1888), descriptions are mostly restricted to a few scientific publications in professional journals, such as Flora (1904), where C.A. Fenner (Germany) provided wonderful and very detailed botanical drawings of *D. rotundifolia* and other carnivorous genera (Fenner 1904). Investigations on the movement of *Drosera* tentacles and how close they are related to the trigger hairs of *Aldrovanda* and *Dionaea* have been published by Prof. Stephen Williams (USA) in the early 1970s (Williams 1976, 2002; Williams & Pickard 1974, 1979). Using minute electrodes, he measured action potentials produced at the head or at the junction between head and stalk by touching or chemical stimulation (*i.e.* with sodium chloride) of the tentacle head. The action potentials move down the stalk where they cause particular cell-groups to increase their inner pressure. Without any junction, the whole tentacle starts bending inward toward the lamina due to rapid cell expansion (called turgor-growth). Stephen Williams examined mucilage producing tentacles of *D. capensis* for his experiments. In the early 20th century, Henry D. Hooker, Jr. (1917) used the fitting term "non-glandular bisymmetric tentacle head" and dedicated his research on "the mechanics of movement in *Drosera rotundifolia*" mainly to the bending stalks of its marginal tentacles. In 1972, H.W.J. Ragetli, M. Weintraub, and Esther Lo (Ragetli *et al.* 1972) described two tentacle structures for the *Drosera* trap "... bisymmetrical tentacles lying in the plane of the leaf blade and extending outward from the leaf margin; and radially or nearly radially symmetrical tentacles extending upwards from the upper surface of the leaf ... composed of an oval shaped head, a cylindrical stalk, and a connecting zone". However, it was worth it to examine numerous species again, because our results show clearly that there are not only more, but even really amazing, adapted tentacles with clearly different morphology.

Drosera glanduligera, the snap-trap sundew

In 1994, we filmed *Drosera burmannii* (section *Thelocalyx*) in our greenhouse to record the rapid movement of its non-glandular elongated marginal tentacles (Hartmeyer & Hartmeyer 2006). Surprisingly, we also found such tentacles with some other sundews standing nearby. Actually, less eye catching, but showing the same tactic, were the hybrids *D. capensis* × *aliciae* and *D. rotundifolia* × *spatulata* (synonym: *D. tokaiensis*), some African species (section *Drosera*), as well as some pygmy *Drosera* (section *Bryastrum/Lamprolepis*). We found it very interesting that some species showed this feature and others not. We kept the phenomenon in mind for a future project.

In 2003, we received the above mentioned parcel from Richard Davion. He wrote about "Ribbon Tentacles" on *D. glanduligera* (monotypic section *Coelophylla*) which need only fractional parts of a second to bend. In 1995 and 1999, he even published articles on the subject in "Flytrap News"

(Davion 1995, 1999) mentioning also the movement of *D. burmannii*, *D. pygmaea*, and *D. callistos*. This proved to be in vain, because obviously CP enthusiasts either ignored or did not believe him – until we showed his VHS recordings on our DVD "A Hunting Veggies Cocktail" (Hartmeyer & Hartmeyer 2004). For our own experiments, we used a PAL video camera (25 pictures per second) for speed measurements and were able to prove with single pictures that, triggered with a tooth pick or tweezers, *D. glanduligera* moves its elongated marginal tentacles within sensational 0.16 (±0.04) seconds like a snap trap, which set a unique record for the genus and is as fast as the Venus Flytrap snaps shut. In addition, our attendant microscope pictures show a clearly distinct tentacle morphology (see below), again unique for the whole genus. Also, the ontogenetic development of its seedlings is clearly different from other species. So we thoroughly confirmed Davion's discovery, and wrote an article for the German CPS (GFP) newsletter Das Taublatt (Hartmeyer & Hartmeyer 2005). With our publication, we coined the term "snap-tentacle" in English and, after a proposal by Dr. Jan Schlauer, the term "Schnelltentakel" in the German language. A new video showing the snap-tentacles of *D. glanduligera* in action can meanwhile be seen on YouTube (*Drosera glanduligera* snap-tentacles: http://www.youtube.com/watch?v=_q4daCCHKoQ).

A new diversity of tentacles

Already in the early state of our experiments with rapid moving marginal tentacles, but increasingly after our examination of *D. glanduligera*, our macro-shots and microscope pictures disclosed a clandestine diversity, demanding an even closer inspection. Amazed about different shapes, speed, and the spasmodic appearance even in closely related species, we realized that these results contain not only obvious information about adaptation and relationship within the genus, but also on the evolution of the whole family Droseraceae.

Beside the "normal" symmetrical mucilage-producing tentacles growing upright on the lamina, we identified three different types of marginal tentacles. We also found additional non-glandular structures like the unique yellow-shining lens-headed tentacles at the base of the trapping leaves and at the bracts of the florescence of *D. hartmeyerorum* (section *Arachnopus*). The head consists of lens-like transparent giant cells focusing at a bright yellow cell-structure in the center. Reflecting the incoming sunlight, these lens-tentacles function like a yellow rear reflector (Hartmeyer & Hartmeyer 2006). Additional lens-tentacles, placed at intervals on the dark red bracts of the green florescence, look like a chain of runway lights from above, attracting insects (we found lots of baby grasshoppers) to walk or skip down the flower stalk into the dark red and sticky plant center from where bundles of lens-tentacles show the yellow lightning with high contrast. We also found different small 0.1 to 1 mm-sized emergences with a simple yellow hemisphere-shaped head on the trapping leaves and stalk of Australian *D. indica*, and translucent mushroom-like emergences with a waved flat head on a large African *D. indica* (Hartmeyer 2003; Hartmeyer & Hartmeyer 2006). We guess that the mushroom-like structures produce the sweet odor of that intensely scented plant. From personal communication, we know about some more different emergences on sundews which are still subject to further examination and have not been published yet. Our examinations on the lens-tentacles can meanwhile be seen on YouTube: "Sophisticated survival strategies of the annual *Drosera*" http://www.youtube.com/watch?v=_TkGTiqkDlY.

These findings produce an increased understanding about the connection of marginal tentacles with the other genera assigned to the Droseraceae: *Aldrovanda* and *Dionaea*. Their modified non-glandular tentacles should not be forgotten. These are the trigger hairs on the snap-traps of both genera that developed from *Drosera* tentacles, as Stephen Williams described in the 1970s. But, also,

Figure 1: *Drosera scorpioides*, T1 sticky marginal tentacles. Photo by E. Pöhlmann.

the spine-like teeth on the margin of *Dionaea* lobes are obviously a remnant of marginal tentacles which lost their (no longer needed) trigger function.

Three different types of marginal tentacles

Concerning the rapid moving marginal tentacles of *Drosera*, we confine ourselves only to the three types of "modern" tentacles that all emerge with a very broad and powerful base (four to six times broader than the base of the cylindrical tentacle stalks on the lamina) lying in the plane of the leaf blade. The following definition was published in 2008 (Hartmeyer & Hartmeyer 2008; McPherson 2008).

The first type of marginal tentacles (T1, present mainly on the leaves of erect growing species) possess a mucilage producing, glandular symmetrical head which is similar to the normal stalked mucus secreting glands on the lamina of that species, however, develops on an elongated stalk that emerges with a very broad base. This type of elongated marginal tentacle is typified on the lamina of *D. scorpioides* for example (see Figure 1). Movement in this type of tentacle takes place by turgor growth.

The second type of marginal tentacle (T2, present mainly on the leaves of basal rosettes) possess a bisymmetrical, non-glandular head that lacks a sticky mucus secretion, often looking somewhat like a shovel with a flat lower side and an elevated mostly red, rarely green colored cushion-like glandless cell structure on the upper side, which develops on an elongated stalk that emerges with a very broad base. The size and shape of the elongated head and stalk vary considerably within different species. This type of elongated marginal tentacle is typified on the lamina of *D. burmannii* for example (see Figure 2). Important: T2- tentacles always lack secretions of glue and movement takes place by turgor growth.

The third type of marginal tentacle (T3) is known only from *D. glanduligera* (see Figure 3). The stalk consists of a broad lower section emerging with a very broad base from the margin of the lamina and, connected by a kind of junction, a very slender but longer upper portion that terminates in a bisymmetrical, non-glandular head that lacks sticky mucus (see Figures 4 and 5). Evidently, the tentacle head contains a trigger mechanism, which when activated, causes the tentacle to move very rapidly. The slender upper part of the tentacle bends forward from the junction-like midsection so that the head of the tentacle snaps towards the middle of the lamina (see Figure 6). The whole process takes place remarkably quickly; we measured 0.16 seconds. The process of movement and the morphology of T3-tentacles differ therefore from all other tentacles known from the foliage of species of *Drosera*. The mechanism by which movement takes place is not currently understood. It is possible that some turgor growth takes place in order for the tentacle to bend, however, the process overall is much more sophisticated and therefore *D. glanduligera* is (until today) the only sundew that moves with the same speed as the Venus Flytrap.

We define a snap-tentacle (T2 + T3) as a structure which emerges with a powerful broad base from the margin of the lamina, consists of an elongated stalk with or without junction, and a bi-

symmetrical non-glandular head. This definition includes the second and third type of elongated marginal tentacles described above, but not the first type, as despite its powerful broad base and often rapid movement, T1 carries a mucilage producing, glandular symmetrical head (much like those of regular tentacles common to the leaves of all species of *Drosera*). Any tentacle with a conventional mucus secreting head is therefore not a snap-tentacle.

Both types of snap-tentacles are able to bend rapidly, although through different processes and at very different speeds. T3-tentacles move 50 to 100 times faster than T2-tentacles. Since both types are non-glandular, it seems likely that they primarily play the role of ensuring and fixing prey to the center of the lamina, and so, to complicate an escape and/or to avoid the theft of prey by cleptoparasites. Not to forget, usually behind the front row of snap-tentacles follow 1-3 rows with smaller and more upright-held sticky T1 tentacles, which develop also with the typical broad base (unlike the normal upright glue-tentacles on the lamina) and support the snap-tentacles in fixing prey.

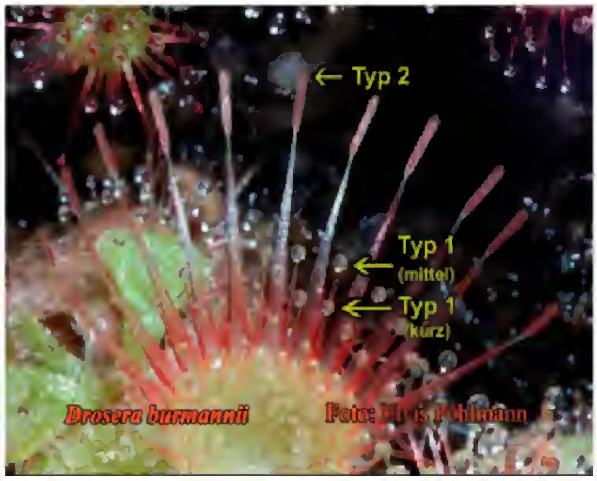

Figure 2: *Drosera burmannii,* T2 + T1 tentacle pattern on adult plant. Annotated by S. Hartmeyer.

Figure 3: *Drosera glanduligera,* T3 + T1 tentacle pattern on adult plant. Annotated by S. Hartmeyer.

Archaic and modern *Drosera*

During our experiments, it became clear that the ontogenetic development of the seedlings also deserves a closer investigation. Surprisingly, many seedlings possess leaf generations (which follow the cotyledons) with a minimum of three to five powerful snap-tentacles (T2) which emerge morphologically as outgrowth of the lamina, but many of the adult plants do not.

Unfortunately, we were not able to get seeds from *D. arcturi*, *D. regia*, and section *Prolifera*. Therefore, these species were examined for snap-tentacles looking at the first leaves of small plantlets, which grew from root- or leaf-cuttings (*D. adelae*, *D. regia*, and *D. schizandra*), developed at the florescence (*D. prolifera*), or opened first from winter resting buds (*D. arcturi*). The results show clearly that juvenile plants of the oldest known species in the genus, *D. arcturi* and *D. regia*, never develop broad-based marginal tentacles (T1-T3). This confirms the assumption that the first sundews caught their prey only with simple glue-tentacles on the lamina, but had already developed the ability to roll the complete leaf.

Also, the species in section *Arachnopus* (*D. hartmeyerorum*, *D. indica*), and section *Prolifera* (*D. adelae*, *D. prolifera*, *D. schizandra*) seem to descend from archaic species because here we found no snap-tentacles. However, one exception in section *Prolifera* is *D. adelae*, which pos-

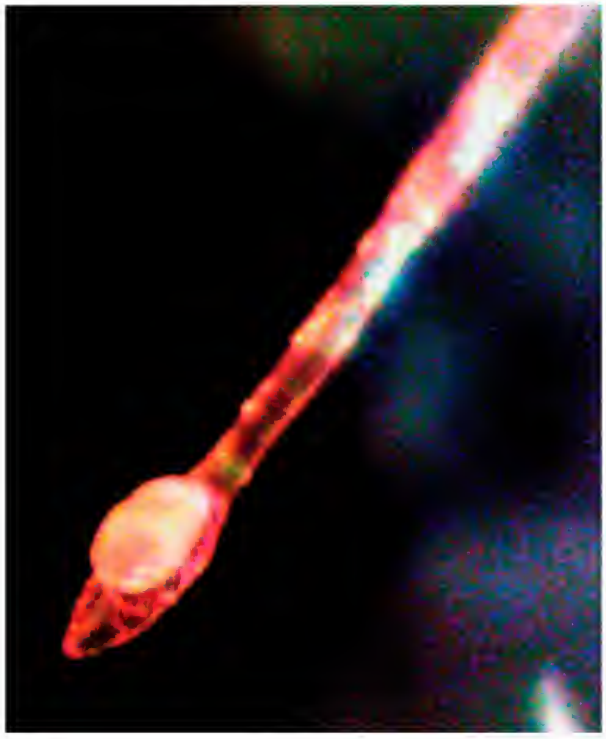

Figure 4: *Drosera glanduligera,* tentacle head. Photo by S. Hartmeyer.

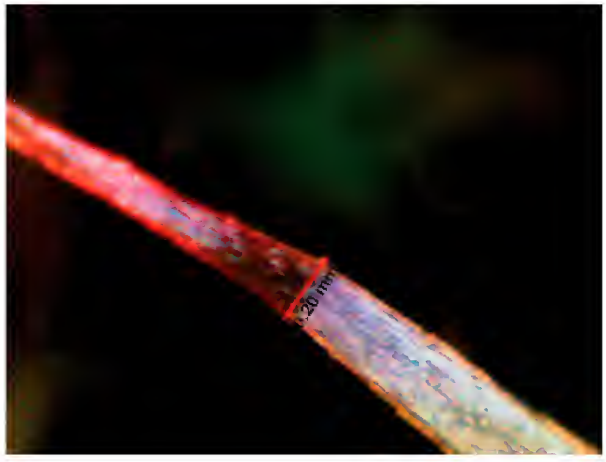

Figure 5: *Drosera glanduligera,* outstretched snap-tentacle with junction in the middle. Photo by S. Hartmeyer.

sess some tentacles at the leaf-tips which also emerge from a broad base and are able to move faster (45–90 seconds) than the other tentacles on the lamina; therefore, they show some similarity to T1 tentacles. This may be a sign that section *Prolifera* is somehow in between the archaic and modern *Drosera*, but its tentacle structure is more closely related to the modern section *Drosera* than to section *Arachnopus*. This would also subsequently confirm Jan Schlauer's decision (Schlauer 1996) to extract the Queensland sundews from section *Arachnopus* into its own section *Prolifera*. Unlike all species which developed elongated marginal tentacles to fix prey to avoid theft by clepto-parasites, the species in section *Arachnopus* adapted and optimized their tentacles obviously to increase the attraction of prey.

The tuberous sundews (section *Ergaleium*) deserve further attention. Neither seedlings nor adult plants possess snap-tentacles (T2 + T3), but mainly the erect species show typical broad-based marginal T1-tentacles. As we documented with *D. macrantha* (Hartmeyer & Hartmeyer 2006), when triggered, they bend with about the speed of *D. burmannii*. This is actually a very modern feature.

Without a doubt, something substantial must have happened in the past that triggered the development of powerful broad-based marginal tentacles to fix prey to the lamina, maybe to improve digestion, but more likely to complicate the theft of prey. With this important adaptation, the modern *Drosera* turned up, becoming so successful that nowadays all (examined) species world-wide assigned to the sections *Bryastrum/Lamprolepis*, *Drosera*, *Lasiocephala*, *Meristocaulis*, *Phycopsis*, *Ptycnostigma*, *Stelogyne*, and *Thelocalyx* descend from the first modern sundews, all starting their life as a seedling equipped with powerful T2 snap-tentacles.

Therefore, we define all species which develop either T1- or T2- or T3-tentacles as modern *Drosera* and those without these broad based marginal tentacles as archaic *Drosera* (see Table 1).

As mentioned above, *D. glanduligera* develops very effective and unique tentacles. At a first glance, the fastest snap-mechanism of the genus seems to be the most sophisticated and, therefore, very modern. Using a magnifying glass, we observed that minute springtails were catapulted into

the sticky center of the lamina after touching the unique snap-tentacle extending from the lamina —like the alarm threads of some spiders. But strange enough, its seedlings start with first leaf-generations (after the cotyledons) that possess only T1 stalked glands, even the next two or three leaf generations show only gluey and intermediate (between T1 & T3) tentacles. Only from the fourth or fifth leaf generation on, the typical rapid moving snap-tentacles with the junction-like middle-part function are found. Therefore, the ontogenetic development is distinct from all other species (examined so far) in the genus and therefore *D. glanduligera* must be considered as the oldest of the described modern sundews.

Basal rosettes and erect plants

In section *Bryastrum/Lamprolepis*, for example, we find a lot of adult plants that possess very prominent snap-tentacles, but closely related species growing sometimes at the same site, do not. This confusion disappears immediately if the growing shape is taken in consideration, as shown in Table 2. This pattern is typical for the species assigned to the modern sections and shows clearly that snap-tentacles are very important for seedlings and basal rosettes, but obviously not for erect plants. If the fixing of prey to the lamina would have been developed only to improve digestion, it should be useful for both basal and erect plants, but if the fixation is a strategy to avoid the theft of prey—which happens frequently, for example, by ants—the strategy is only important for trapping leaves near the soil (*i.e.*, seedlings and basal rosettes). Erect growing plants, like *D. scorpioides* or *D. madagascariensis*, but also erect-held leaves, such as on adult *D. capensis* or *D. binata* (all seedlings and juvenile plants possess T2-tentacles), catch mostly flying insects, for which their sticky T1-tentacles work much more effectively. Just a little contact with the tip of a wing is sufficient to paste and hold a mosquito. The speed of movement achieved by T2-tentacles may be impressive for a plant, but is certainly not dangerous for flying insects.

Drosera of the Northern Hemisphere

Referring to the whole genus, only a small number of species grow in the Northern Hemisphere. While species like *D. capillaris* and *D. spatulata* remain relatively south, preferring warmer temperatures, *D. anglica*, *D. intermedia*, *D. linearis*, *D. rotundifolia*, and a little less tough *D. filiformis*, show a perfect adaptation to frost and short growing seasons by developing a true dormant

Table 1. Distribution of snap-tentacles (T2 & T3) in *Drosera* sections (incl. seedlings).

Section	Snap-tentacle type	Section	Snap-tentacle type
Arachnopus	- - -	*Meristocaulis*	T2
Arcturi	- - -	*Phycopsis*	T2
Bryastrum/Lamprolepis	T2	*Prolifera*	- - -
Coelophylla	T3	*Ptycnostigma*	T2
Drosera	T2	*Regia*	- - -
Ergaleium	- - -	*Stelogyne*	T2
Lasiocephala	T2	*Thelocalyx*	T2

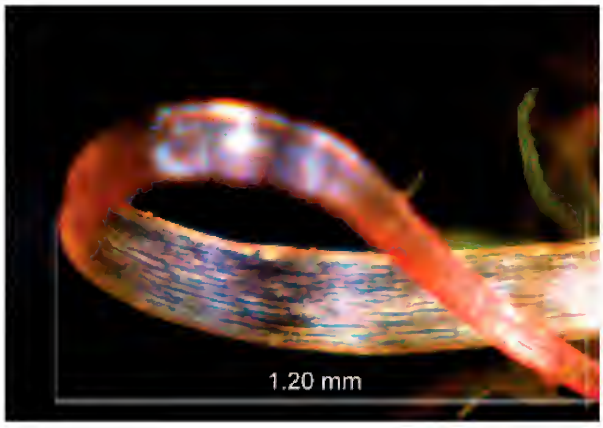

Figure 6: *Drosera glanduligera,* triggered snap-tentacle, bend at the junction. Photo by S. Hartmeyer.

bud. All species are assigned to the modern section *Drosera* and all of their seedlings possess snap-tentacles. However, the only typical basal rosette is *D. rotundifolia*, and confirming the above mentioned pattern for the growing shape, only this true northern species develops T2-tentacles on adult leaves not always and not every leaf, which caused a little confusion when we examined our greenhouse plants for our video and found not one snap-tentacle on any of our plants. But in the next season—after the video has been edited—the same plants developed them. None of the species growing in colder regions of the Southern Hemisphere, neither the simple winter bud of *D. arcturi* nor the thickened roots of *D. binata* or *D. cistiflora* are able to survive temperatures below -20 or even -30 degrees centigrade, which is no problem for the specialized hibernacula of the northern species. A less effective adaptation to frost in the Southern Hemisphere is not illogical if one considers that the northern ice shields moved much further south (and back), occupying much more land than the Antarctic ice shields, which show even today still about 80% of their maximum extension during the last glacial period about 20,000 years ago. So we can assume that the species of the Northern Hemisphere developed their strategies to survive extreme frost during the approximately 30 glacial periods within the last 2 million years.

Drosera of the Southern Hemisphere

The predominate number of *Drosera* can be found in the Southern Hemisphere. *D. regia* in South Africa and *D. arcturi* in Australia/New Zealand are the oldest known species and most experts agree that the genus developed in the south, spreading north over the course of time. As mentioned above, only modern species can be found north of Australia and South Africa, and surprisingly, the shape of their T2-tentacles seems to provide further information about their history. However, most T2-heads on seedlings and young leaves are round, or in *D. binata* sometimes nearly square, so only the shape of heads on adult leaves should be compared.

Let's start in Australia, where we find more than 100 of the approximately 180 species worldwide (estimated, because new species are frequently found). As mentioned above, *D. glanduligera*, due to its ontogenetic development, is probably the oldest of the modern *Drosera*. The greatest morphological similarity with the unique T3-tentacles of *D. glanduligera*, and therefore indicating the closest relationship, are the T2-tentacle heads of pygmy *Drosera*, where we find also very long slender stalks with minute round heads. Actually, we also found the fastest T2-movement in this section with *D. ericksoniae*. Five seconds to bend to the lamina is indeed fast, however, still a magnitude slower than *D. glanduligera*. The large dichotomous leaves of *D. binata* (section *Phycopsis*) possess only mucus-producing T1-tentacles, but seedlings and juvenile plants develop T2-tentacles until the lamina starts to divide.

Drosera burmannii, with very prominent snap-tentacles, shows the largest rectangular heads in the genus, referring to the plant size. It was in the past often called the fastest moving sundew, but with 8-15 seconds measured it is not faster than many pygmys. The only species in Australia

Table 2: Examples for tentacle types in relation with the growing shape.

Section	Species	Seedling	Adult	Growing shape
Arachnopus	*D. hartmeyerorum*	- - -	Lens-tentacles	Erect
"	*D. indica* (all varieties, probably even undescribed species)	- - -	different small emergences	Erect
Arcturi	*D. arcturi*	- - -	- - -	Rosette, erect leaves
Bryastrum/Lamprolepis	*D. callistos*	T2	T2	Basal rosette
"	*D. ericksoniae*	T2	T2	Basal rosette
"	*D. occidentalis*	T2	T2	Basal rosette
"	*D. pulchella*	T2	T2	Basal rosette
"	*D. pygmaea*	T2	T2	Basal rosette
"	*D. dichrosepala*	T2	T1	Erect
"	*D. enodes*	T2	T1	Erect
"	*D. lasiantha*	T2	T1	Erect
"	*D. scorpioides*	T2	T1	Erect
Coelophylla	*D. glanduligera*	T1	T3	Basal rosette
Drosera	*D. aliciae*	T2	T2	Basal rosette
"	*D. capensis*	T2	T1	Erect
"	*D. madagascariensis*	T2	T1	Erect
"	*D. ramentacea*	T2	T1	Erect
"	*D. rotundifolia*	T2	T2	Basal rosette
"	*D. spatulata*	T2	T2	Basal rosette
Ergaleium	*D. erythrorhiza*	- - -	- - -	Basal rosette
"	*D. bulbosa*	- - -	- - -	Basal rosette
"	*D. lowriei*	- - -	T1	Basal rosette
"	*D. macrantha*	- - -	T1	Erect
"	*D. modesta*	- - -	T1	Erect
"	*D. peltata*	- - -	T1	Erect
Lasiocephala	*D. lanata*	T2	T1	Rosette, erect leaves
"	*D. ordensis*	T2	T1	Rosette, erect leaves
Phycopsis	*D. binata*	T2	T1	Rosette, erect leaves
Prolifera	*D. adelae*	- - -	resemblance with T1	Basal rosette
"	*D. prolifera*	- - -	- - -	Rosette, erect leaves
"	*D. schizandra*	- - -	- - -	Basal rosette
Ptycnostigma	*D. cistiflora*	T2	T1	Erect
Regia	*D. regia*	- - -	- - -	Rosette, erect leaves
Thelocalyx	*D. burmannii*	T2	T2	Basal rosette
"	*D. sessilifolia*	T2	T2	Basal rosette

assigned to section *Drosera* showing rectangular heads is *D. spatulata*. But both *D. burmannii* and *D. spatulata* also grow further north in Asia and seem to be not typical of Australians. The clear majority there show round to slightly oval heads.

Most of the species growing in the Americas are assigned to section *Drosera*. Unfortunately, we had only few plants to examine, but it's interesting that several species like *D. montana*, *D. capillaris*, *D. felix*, but also young plants of *D. ascendens* and *D. villosa* (the last two species have only T1-tentacles when matured) show a somewhat more three-cornered than true rectangular shape, which seems to be an American feature. But, as in Australia, we find also a few species that do not fit. *Drosera sessilifolia* (section *Thelocalix*) is only hard to distinguish from *D. burmannii* in Australasia and its snap-tentacles move with the same speed. The recently discovered *D. meristocaulis* (section *Meristocaulis*) develops snap-tentacles and is surprisingly very similar to the Australian pygmy *Drosera*. *Drosera rotundifolia* growing only in colder climates from North America through Europe and Siberia to Japan shows more rectangular heads.

Most of the African species are also assigned to section *Drosera*, but *D. admirabilis*, *D. aliciae*, *D. cuneifolia*, and most of the other examined plants possess large rectangular T2-tentacle heads like *D. rotundifolia* or *D. spatulata*. In this connection also, the rectangular heads of *D. burmannii* (Australasia) and *D. sessilifolia* (South America) should be mentioned again. A good example for the development of modern tentacles during the maturation of erect plants is the South African *D. cistiflora* (section *Ptycnostigma*) which has first round, later drop-shaped T2-heads as long as it grows as basal rosette, but only two or three leaf-generations after the erect growth started, only sticky T1-tentacles appear in their place.

Looking at the morphology, the majority of species in Australia develop round-shaped T2-heads; in Africa, we find mainly rectangular heads; and in the Americas, the lower part of the cushion-like cellstructure is often a little smaller than the upper part, so they appear more wedge-shaped. That looks very much like a separated development on each continent, but from common ancestors. A development, that is similar and well known also from other plant genera (*i.e.* Proteaceae), was caused by the continental shift which separated the southern continents more than 100 million years ago. If this can be confirmed by other scientific methods for the genus *Drosera*, we have—even without usable fossils—a good evidence that carnivory is actually a very old strategy within the plant kingdom, existing even in Gondwana, the giant continent in the Southern Hemisphere which broke apart into Antarctica, Australia, Africa, India, and South America between 130 - 100 million years ago, so the archaic sundews must even be considerable older. This theory would also provide a logical explanation for the occurrence of obviously closely related species on different (now) remote continents.

Conclusion

If we summarize all of the observations mentioned above and combine them with scientific confirmed incidents, a surprising theory (to be confirmed by other scientific disciplines) can be expounded:

Once upon a time, 200 or maybe even 300 million years ago, archaic vertebrates, plants, and arthropods like millipedes, insects, mites, and spiders, were living in the tropical rainforests at the southern coastal regions of Gondwana, an area that corresponds today mainly with Antarctica, but also the southern tip of South America in the west and Australia in the east. Certainly different from today, but following the same principles of life as nowadays, food chains and a web of interdependence including mutualism and parasitism developed. This interrelation en-

abled a group of early angiosperms (flowering plants) to use the manifold arthropods for their sexual reproduction. Compared with pollination by wind, animal-assisted pollination is much more beneficial because only a fraction of the pollen is necessary if it is carried by animals specific to the females. As a result, the modern insect-attracting flowers and a new web of interdependences developed.

Today all known carnivorous plants are angiosperms, so it is only logical to consider that they also realized very soon that arthropods attracted by provided nectar are not only good to transport pollen, but are also compact protein-packs which can be used very efficiently as nutrients, providing a certain advantage on poor rainforest soils. Therefore, some angiosperms started to catch prey with sticky tentacles on the surface of their leaves (and others probably also with pitcher forming leaves) and learned in the course of time to produce digesting enzymes and glands to absorb the nutrients. Thus, the archaic sundews, looking probably somewhat like *D. schizandra* or *D. regia* started their successful existence.

About 130-140 million years ago, these archaic *Drosera* had conquered the whole south of Gondwana, but now some wasps decided to settle on the ground and to use wings only for their mating flights. As a result, one of the most successful genera on earth appeared: the ants. Without a doubt, the appearance of ants caused a kind of revolution for all organisms living on the ground. Even today, it can be frequently observed that ants, which are certainly also prey for *Drosera*, steal considerable amounts of prey that the sticky plants caught. So, with the ants, the quantity of nutrients became suddenly seriously reduced. The ability to roll in leaves to hold captured prey more effectively and to increase the surface for digestion was too slow to avoid the theft by the omnipresent ants (and/or other clepto-parasites). But as part of the never ending story in nature to become the fittest survivor, some *Drosera* developed marginal tentacles equipped with a powerful broad base and the ability to move rapidly enough to fix the prey effectively before predatory ants are able to steal it. With this successful adaptation, the modern *Drosera* saw the light of day. During the following millions of years, new *Drosera* species and even two new genera changed the sticky and snap-tentacle armed trap into a closing snap-trap (which is even more effective to prevent the theft of prey), prospered well and proliferated north.

Caused by the continental shift, Gondwana broke asunder into the new southern continents and as early as 100 million years ago, the oceans in between became so large that the now separated species on the divided landmasses developed independent from each other. Antarctica, the area where probably the first *Drosera* developed, became isolated in the polar region and the archaic life was killed by frost. Australia, the last continent that broke away from the east of Antarctica drifted toward the equator and carried so many Gondwana species, like the marsupials, that it is now the epicenter with the most descendants of archaic and modern *Drosera*. South America broke away from the west of Antarctica earlier, but different species like *D. sessilifolia* and *D. meristocaulis*, with obviously closely related plants in Australia, may be evidence for common ancestors in Gondwana. Also, in South Africa, which separated even earlier, *D. indica* and numerous modern species survived, including the most archaic *D. regia*, which has several similarities with the Australian (and New Zealand) *D. arcturi*.

When our first observations and investigations on the movement and different shapes of elongated marginal tentacles started, it was interesting from the beginning, but we never expected how much new information can be collected even today using a simple microscope. Most of our published results have meanwhile been confirmed and supplemented by other CP-experts and authors. However, as mentioned before, our conclusion supporting the so called "Gondwana theory" should soon be confirmed by other scientific disciplines.

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Prey Preference in *Genlisea* Small Crustaceans, Not Protozoa

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Keywords: cultivation: carnivory: amphipods, copepods, protozoans, *Genlisea.*

Introduction

It has been reported that *Genlisea* (see Back Cover) is a plant which specializes in trapping ciliate protozoa, such as *Blepharisma*, which it has chemotactically attracted, and it was claimed further to be the first such example known (Barthlott *et al.* 1998). Those authors used both South American (*G. aurea*, *G. violacea*) and African (*G. margaretae*) species for their work, and they found or were able to cite evidence for prey being attracted by means of released chemicals, for the release of digestive enzymes, and the absorption and translocation of radioactive ^{35}S (Barthlott *et al.* 1998).

However, a number of questions have been raised about this claim (Plachno *et al.* 2005a). First, the prey offered to the plants in the experiments described above may be very different from the prey which these plants would encounter in nature, making the identification of *Genlisea* as specializing in trapping protozoa suspect. Naturally occurring organisms which might serve as prey might also include small crustaceans and other small animals such as water bears.

Second, while the mechanism of the trap was at one point proposed to involve flow of water, and which might be ideal for capture of protozoa (Meyers-Rice 1994), it was subsequently found to have no water flow involved (Adamec 2003). Instead, the mechanism seems to involve both inward-pointing hairs and mucilage (Stuidnicka 2003a, 2003b) which help to point potential prey into the digestive bulb of the trap and to prevent their escape. Given the presence of the mucilage and hairs, these traps may be difficult for small protozoa to enter and may be adapted more for catching larger, stronger, more nutrient-rich prey like small crustaceans which are better equipped to enter the traps.

To test the prey spectrum of *Genlisea*, experiments were performed using *G. filiformis* from South America; 1) to determine which types of prey organisms were preferentially trapped when a mixture of prey was presented to the plants and 2) to determine whether the released chemoattractants affected ciliate protozoa, as suggested by Barthlott *et al.* (1998).

Materials and Methods

Genlisea filiformis plants from old tissue cultures, originally made on 1/5-strength tissue culture media (Darnowski 2004), low in nutrients were used, after hardening off on soil (sand-peat mixture). This ensured that plants were not well-stocked with nutrients and thus prevented high nutrient levels from reducing the drive for carnivory.

For the first type of experiment, repeated thrice, plants were placed in a dish with their white trapping leaves in filtered pond water. Then, potential prey were added as follows: 3 drops of a culture of *Blepharisma* sp., a ciliate protozoan used by Barthlott *et al.* (1998; provided hundreds of organisms); 3 drops of a culture of *Euglena acus*, a flagellate protozoan (hundreds of prey provided); 4 drops of a culture of *Hypsibius* sp., a waterbear (animal phylum, size of a typical 10µm protozoan; dozens to hundreds provided); 3 drops of a culture of copepods (*Cyclops* sp.), a small crustacean (about 10 provided); 3 drops of a culture of amphipods (*Gammarus* sp.), a small crustacean about 10 times larger than *Cyclops* (about 5 provided). Organisms were left with the plants for 1 week, and then trapping was scored using a dissecting microscope.

For the second type of experiment, bactoagar cubes approximately 0.5 cm (0.2 in) on a side were placed either in pond water (control) or under the trapping leaves of *G. filiformis* growing in soil for 1

week to allow absorption of chemicals from the local environments. Chemoattractants from *G. filiformis* should have been absorbed during this time by the agar cubes. These were then placed in the center of 100 mm plastic petri dishes in filtered pond water, and prey were added as noted above except for amphipods, since these were never trapped in the first type of experiment. After about a half-hour for equilibration and diffusion of chemoattractants, the position of prey of each type was found for about 5 individuals found by randomly selecting fields of view around the dish under a dissecting microscope. Position was recorded relative to the agar cube. The mean distance from the block was determined for each prey item, and the experiment was repeated three times. Then, the overall mean and the standard error of the mean were calculated for each prey item across the three repetitions.

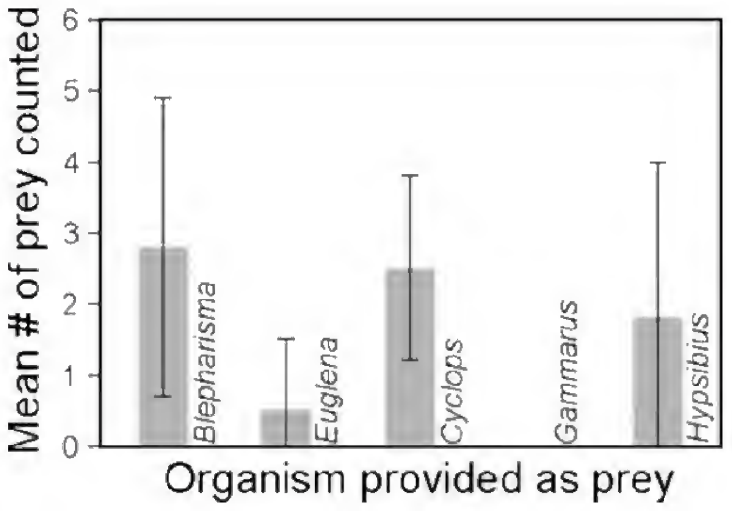

Figure 1: Prey counted in *Genlisea filiformis traps*. *Blepharisma*: 2.8±2.1, *Euglena*: 0.5±1, *Cyclops*: 2.5±1.3, *Gammarus*: 0.0, *Hypsibius*: 1.8+2.2.

Results

As can be seen from Figure 1, the G. filiformis plants never trapped amphipods, and they trapped about the same number of copepods as other prey, all of the other prey being much smaller than the copepods.

Figure 2 shows the results of the experiment with chemoattractants absorbed by agar blocks. The data are graphed with 2.5 cm subtracted from each distance. This was done to emphasize whether position was random or not, since 2.5 cm is the average distance from the center of the dish to the edge. If prey were distributed away from the agar block in no particular position, a mean distance of 2.5 cm would be expected. Negative numbers indicate closer placement towards the agar block, demonstrating attraction by the block/chemicals diffusing from it, and positive numbers indicate movement away from the block, i.e. repulsion by released chemicals. The distance from the center of the dish at which a circle can be drawn to evenly divide the area of the dish into two parts is at about 3.6 cm, based on simple geometric considerations. However, given that the dish has a reflective edge at the outside of the dish but not at the center, and such an edge might well deter negatively phototactic prey, the experimenter has chosen the midpoint of the radius of the dish, 2.5 cm, instead. Even if the data were recentered around the 3.6 cm line, the basic conclusion of this paper would not be changed.

Discussion

From the data presented, clearly prey preference in *Genlisea* is for small crustaceans, not protozoa. Figure 1 shows that *G. filiformis* trapped relatively few prey of any type, but the prey counted most frequently were the protozoan *Blepharisma* and the copepod *Cyclops*. However, the protozoan prey were presented with an abundance of approximately 10 times that of the copepods. Therefore, the plants trapped a much higher percentage of the copepods than any other type of prey. This tends to contradict the conclusions of Barthlott *et al.* (1998) that *Genlisea* specializes in trapping protozoa.

Further, from Figure 2, *Blepharisma* seems to be neither attracted nor repulsed by either control or *Genlisea*-blocks of agar. Other prey, including copepods, stayed further than 2.5 cm from the blocks for controls but came closer than 2.5 cm to the *Genlisea*-block. This may show that chemoat-

tractants had been absorbed by the blocks and that some prey were indeed attracted by them, including the flagellate protozoan *Euglena acus*.

Taken together, these two experiments suggest that *Genlisea* does emit water-soluble chemoattractants which do attract a range of prey, both protozoa and animals. Further, proportionally more copepods were trapped than protozoa, and each copepod contains far more resources than each protozoan. Thus, the conclusion of Barthlott *et al.* (1998) that *Genlisea* specializes in trapping protozoa is probably incorrect.

This study does not address issues of the differential stability of the remains of different prey. Certainly crustacean prey with their indigestible chitinous exoskeletons would leave longer-lasting traces than easily-digested protozoa and might be overrepresented in the data here. However, given that crustaceans are generally much larger than protozoa and provide much more nutrients per prey caught, the data shown here do contradict the previous assertion that *Genlisea* specializes in protozoa.

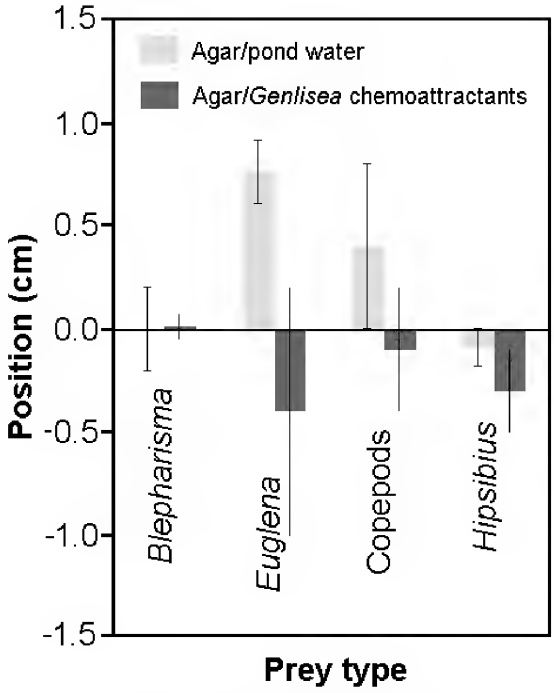

Figure 2: Distances of prey, minus 2.5 cm, from the *Genlisea* or agar block bait.

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Keywords : cultivar: *Pinguicula* 'Johanna', *Dionaea muscipula* 'Coquillage', *Dionaea muscipula* 'Alien', *Sarracenia* 'Johnny Marr'

Pinguicula 'Johanna' (*Pinguicula agnata* × *debbertiana*)

Submitted: 21 August 2010

The hybrid between *Pinguicula agnata* and *Pinguicula debbertiana* was created in 2009. The seeds produced several different-looking plants that belong to the *Pinguicula* Hairy Tongue Group. One of these clones is *Pinguicula* 'Johanna'.

The plant itself is heterophyllous, which in summer has about 25 round leaves (up to 4 cm) that overlap partially, while in winter has about 40 leaves with a length of 2-3 cm. The amount of light on a south facing windowsill is enough to color the plant a nice orange-red (see Figure 1). With poor lighting the leaves are green like those of the parents. Summer rosette is about 9 cm in diameter; winter rosette is smaller about 4-5 cm.

The flower has two upper and three lower petals (which do not overlap) and has a total size of about 2 cm (see Figure 1). Flowering is between March and May, during which 3-6 flowers are typically produced. The color is a light purple, very close to *P. debbertiana* and gets darker in the middle of the flower. The throat instead is nearly white and shows a venation like *P. debbertiana*. Venation is strong in the middle of the flower and becomes hard to see on the outer petal. Like *P. agnata*, the hybrid flower has a strong pubescence, especially on the lower petals and where *P. debbertiana* has it´s typical "yellow brush". The "brush" itself is weakly developed with a white-yellow color.

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Figure 1: *Pinguicula* 'Johanna' plant (left) and flower (right).

Dionaea muscipula 'Coquillage'

Submitted: 11 August 2010

Dionaea muscipula 'Coquillage' was found at the Carniflora open day on May 17, 2008. The traps are well-shaped with widely spaced short teeth and very thick lips (see Figure 2). Traps are usually smaller than 3 cm. The round shape of the traps when closed resembles the shape of a shell. Coquillage means shell in French. Vegetative propagation is necessary to maintain the unique features of this plant.

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Figure 2: *Dionaea* 'Coquillage'.

ERRATUM: The name of Dr. Jang printed in the cultivar description for *Dionaea* 'Korean Melody Shark' published in Carniv. Pl. Newslett. 39: 44–45 was in error and should be corrected to Dr. Gi-Won Jang, not Dr. Jang Gi-Won.

Submitted: 11 August 2010

Dionaea muscipula 'Alien' was found at the Carniflora open day on May 17, 2008. The most spectacular feature of this new cultivar is the extremely arched shape of all of the traps (see Figure 3), which are 4 to 5 cm on mature plants. They made me think of the head of an alien from Ridley Scott's well-known 1979 movie "Alien" (see Figure 4). *Dionaea muscipula* 'Alien' also produces strange teeth that are a little shorter than typical *Dionaea* and have small wings all along the tooth (see Figure 4). Mature traps are also fused at the distal end and base lobes of traps overlap (see Figure 5). Traps do not close well because the lobes of the traps are very heavy, reminding me of a *Heliamphora* pitcher, and when you try to close it with your fingers it often breaks. Each trap produces many tiny trigger hairs (see Figure 6). Vegetative propagation is necessary to maintain the unique features of this plant.

—Guillaume Bily • 56520 Guidel • France • gbily2003@yahoo.fr

Figure 3: *Dionaea* 'Alien' plant.

Figure 4: *Dionaea* 'Alien' teeth.

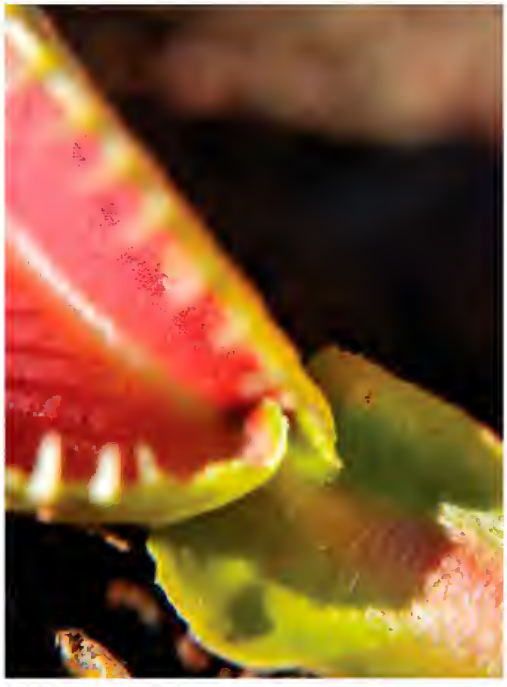

Figure 5: *Dionaea* 'Alien' petiole

Figure 6: *Dionaea* 'Alien' tiny trigger hairs.

Sarracenia 'Johnny Marr'

Submitted: 11 August 2010

Sarracenia 'Johnny Marr' is a 1999 hybrid (*S. flava* var. *cuprea* × S. *purpurea* subsp. *venosa*) × *S. flava* var. *cuprea*. It has strong upright pitchers about 60 cm tall, a large open mouth 5-7 cm across, and an overhanging wavy lid about 12 cm across (see Figure 7). The top two thirds of spring pitchers are a stunning bright copper colour and really stand out in the collection. Later in the season, from the end of June, the pitchers turn a dark burgundy purple all over and the sparse veining is almost black. Flowers are around 10 cm across with pale pink petals. The plant first flowered in 2003 and the bright copper pitcher colour has proved to be stable. The plant was named at the 2010 RHS Flower Show at Tatton Park near Manchester on the 21st of July for the guitarist Johnny Marr (see Figure 8). Propagation is by division only.

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Figure 7: Sarracenia 'Johnny Marr' spring pitchers (left) and fall pitchers (right).

Figure 8: Matthew Soper (left) introduces Johnny Marr to *Sarracenia* 'Johnnie Marr'.

The Savage Garden: "The Legacy of Paul Zahl"

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Keywords: biography: Paul Zahl

Half a century later, the photograph is still an engrossing, eye-filling sight: a Kennedy-era All-American family—a middle-aged Dad with horn-rimmed glasses and pipe, a lip-sticked Mom of fashion-model beauty, and two adorable children, a girl of eleven years of age in a skirt and a boy of eight wearing a polo shirt.

They are all crouched or kneeling on their Washington D.C. patio. A large opened cardboard box marked "Fragile", two dozen sealed plastic bags, a hose, a watering can, and garden tools lie about, and a sizeable screen-topped outdoor terrarium is in the background. There are clods of soil being removed from the bags. The mother is handing one to the father, who holds a trowel. It contains a purple pitcher plant, complete with seed pod. Other lumps of soil sitting on the patio show more pitcher plants and rosettes of Venus flytraps. The little boy is pointing to one as his sister looks on. The caption explains that a fly is buzzing dangerously close to a flytrap, fascinating the children.

This was the Zahl family: Dr. Paul Arthur Zahl, his lovely wife Eda, and their two children, Eda Kristin and Paul, Jr. This photograph—and many others—graced the pages of the May, 1961 issue of the National Geographic Magazine, in Paul A. Zahl's legendary article "Plants That Eat Insects." It was probably the single greatest event in the middle part of the last century that would trigger the later slow-motion explosion of interest in carnivorous plants (CP) all over the world. I know this because it catapulted me as it did many others in the 1960s and early 1970s, when popular literature on the plants was seriously lacking.

The National Geographic Society, begun in 1888, needs no introduction. Most famous for its colorful and educational magazine that is found in many homes, libraries, and dental waiting offices, they also are known for their popular museum and headquarters in Washington D.C., and for hosting educational exhibits and expeditions around the world. More recently their extensive website (www.nationalgeographic.com) and even a cable television station have become part of our modern lives. Go to flea markets or antique stores, and often stacks and shelves of their nostalgic magazines can be found in great numbers.

Paul A. Zahl was born in Bensenville, Illinois in 1910. He was an honors graduate of North Central College in that state, then received his doctorate in experimental biology from Harvard University in 1936, and immediately became notable in cancer research at Haskins Laboratories.

However, he became increasingly interested in natural history and wrote his first book "To the Lost World" in 1939. This was about a trip he took to Mt. Roraima in Venezuela. I have not been able to get a copy of this book, but no doubt Zahl saw *Heliamphora* and other carnivorous plants there. He wrote few books during his long career: "Blindness: Modern Approaches to the Unseen Environment" (1950), "Flamingo Hunt" (1952), and "Coro-Coro: World of the Scarlet Ibis" (1956). Also during this period he did research at New York's Museum of Natural History.

In the 1950s, Zahl concentrated on his writing and photography career with National Geographic. He was senior scientist of natural history for the society from 1958 to 1975. His 1954 article for the magazine, "In the Wilds of a City Parlor", was a very popular piece on how, in their New York City apartment, he and his wife Eda maintained various aquariums and terrariums, re-creating habitats for fish, insects, amphibians and reptiles—including a terrarium of carnivorous plants. This article had an enormous influence on the popularity of exotic creatures as pets.

Figure 1: Paul Zahl and family create a terrarium (from left, Eda Kristin, Mrs. Eda Zahl, Dr. Paul Arthur Zahl, Paul F. M. Zahl). Photo from the Paul Zahl collection.

In fact, his 1959 article, "Little Horses of the Sea", caused me, a decade later, to raise seahorses throughout high school. Zahl's engaging writing style, beautiful photography, and family-oriented story telling was enough to get many readers hooked on such hobbies.

Paul Zahl wrote more articles for National Geographic than anyone else in its long history, over fifty articles from 1946 to 1976. He always chose his subject matter and was never assigned them, and all the photography was taken by him. He wrote about coral reefs and volcanoes, giant frogs, scorpions, man-of-war jellyfish, piranhas, hatchetfish, butterflies, and slime molds ("The fungus That Walks"). He discovered the tallest redwood tree known at the time in the mid-sixties, which made the magazine's cover.

At least sixteen of the articles included the entire Zahl family as they went off on adventurous vacations exploring the natural world. Up until 1959, the covers of the magazine had the famous yellow border and the black-on-white table of contents, but no photography. When photos were added, Mrs. Zahl was the first human being to grace the cover of the magazine—even diving apparatus couldn't hide her good looks and she became known as the "playgirl of National Geographic".

Zahl wrote prolifically. His articles also appeared in Atlantic Magazine, Scientific American, Scientific Monthly, and in the 1960s he wrote a column for The American Scholar. He won many awards for photography and some of his work is on permanent display in New York's Museum of Modern Art. One can also find his photos for sale on Art.com, including some famously recognizable, like a close-up of a gorilla's face, and of tree frogs.

A full page close-up photo of a bright red, gaping trap of *Dionaea muscipula,* with a housefly entering it, opens Zahl's article "Plants That Eat Insects". The article begins with the Zahl family receiving a large shipment of plants and "acid soil" from the Carolina Biological Supply Company, an enormous supplier of all things scientific that is still in existence today. The family constructs a dog-house sized outdoor bog garden "conservatory" on their sunny patio and two smaller terrariums to house their carnivorous menagerie (see Figure 1).

Zahl then gives a rather good rundown on Venus flytraps, from their discovery by governor Arthur Dobbs in 1760 North Carolina to Charles Darwin's studies of the plant. He speaks of the enigma of the trap's mechanism and the electrical activity discovered. Most enlightening to wannabe hobbyists of that decade (like me at age twelve or so!) was information on the plant's habitat and the fact that the species survives freezes in winter, and the importance of fires to the plants' survival in the wild. Photographs of a germinating seedling and a large plant being fed a fly with tweezers are highlights.

Figure 2: Eda Kristin today, holding the 1961 article by her father in National Geographic. Photo by Mrs. Eda Zahl.

One iconoclastic photo shows young Eda Kristin hand-feeding a bug to a terrarium grown plant (see Figure 2). In 1961 little girls were expected to scream and cringe at the mere sight of a leggy insect —but not in the Zahl family!

Next, Zahl visits The Carolina Biological Supply Company and is accompanied by director of culture, Bill Pendergrass, on a field trip. It is explained that Venus flytraps were protected under North Carolina law, but the company was issued collecting permits to allow them to fill orders from "every State in the Union", mostly to schools.

While hunting flytraps in the wet savannahs near Wilmington, fruitlessly at first, they come upon an "unexpected prize. Here the ground glistened with hundreds of tiny jewel-like clusters" —sundews! A full page close-up of a sundew leaf, its tentacles glittering in the light with globs of lethal glue, was the first of its kind in any popular literature. The leaf was of *Drosera intermedia* but misidentified as *D. rotundifolia*. Another memorable photo was of several tiny *D. capillaris*, on black peat, with a dime for size comparison. Zahl continues by explaining the life-style of sundews and his experiments and photos back at home feeding the plants fruit flies.

Zahl takes his family on a return field trip to the Green Swamp. This time they hunt out *Sarracenia* pitcher plants. Colorful photographs take up three-quarters of the pages. Little Eda and her mom peer down the tubes of *S. flava.* Mrs. Zahl holds back the collar of *S. purpurea* to peak inside. A full page photo of the interior of the pitcher, complete with trapped insects. A startling close-up of a black ant negotiating the treacherous white spines on the blood red background of the leaf—all were haunting images.

Later, on a trip to California, the family visits *Darlingtonia,* the cobra plants. Lovely Mrs. Zahl holds open a cut pitcher to show captured insects, with a clear blue sky and snow-capped Mt. Shasta in the distance. She also examines a thick stand of cobras on a wet slope.

Zahl concludes the story with a bit of humor, talking of the old Man-Eating-Tree of Madagascar. He asks that if anyone encounters such a specimen, he would gladly make room for it in his "already overcrowded garden of carnivores."

Paul Zahl's next article that featured carnivorous plants appeared in the May, 1964 issue. "Malaysia's Giant Flowers and Insect-trapping Plants" told of his nine-week journey to places like Sar-

awak and Sabah in north Borneo, in search of giant *Rafflesia* flowers and *Nepenthes*. With much humor he discusses various topics from headhunting to battling onslaughts of leaches as he searches for the plants with native guides and a 19-year-old American Peace Corpsman named Jim Brock. Zahl's family did not accompany him on this expedition. Too dangerous.

Again, this was the first feature to popularize *Nepenthes* since the old gardening magazines of the 19th century. Zahl's photos of *N. villosa, lowii, ampullaria, gracilis, veitchii,* and *sanguinea* were other-worldly. He described their high elevation habitats as "eerie" and "bewitched".

Informative to say the least, much is discussed about *Nepenthes*, from their intoxicating influence on insect prey to the numerous creatures that live unharmed in the pitchers, like certain tadpoles and red crab spiders. A couple of things made this article most noteworthy. One was that these tropical highland plants lived where the climate at 6,500 feet was not only humid but "sharply cool." Observations like these helped growers cultivate the plants over a decade later as the CP hobby began its modern era.

A second thing was that Zahl introduced to the west a common name for the plants, used by the locals: monkey cups. This term was picked up by Britain's Adrian Slack in his two books that appeared in the late 1970s and early '80s. This term of "monkey cups" has even been applied by locals to native pitcher plants of New Jersey, no doubt influenced by Zahl's article. One person from my home town in that state claimed his grandfather called *S. purpurea* "monkey cups" and his grandfather subscribed to National Geographic in the 1960s. In his article, Zahl photographed an orangutan sipping the liquid of an upper pitcher of *N. rafflesiana.*

With the help of my staff at California Carnivores, I found Paul Zahl's daughter, Eda Kristin, and gave her a phone call. There are two words I can use to describe this articulate, enthusiastic young woman now in her early 60s: "She's swell!" When we first spoke, she was just leaving her southern California home to visit her mother, now 84, in Connecticut. I had a few very informative and exciting conversations with her, including one with a rather vivid and energetic Mrs. Zahl, a humbling experience!

Paul Zahl met Eda Seasongood Field through Paul's brother Harold. Harold Zahl was also famous. He was the inventor of the "Zahl tube", that allowed planes to be detected under radar, which changed the course of World War II. The Zahl brothers – and their siblings – were the offspring of a Lutheran minister. Eda Field was a Christian Scientist and later raised her two children under that religion. "Our upbringing was a combination of spiritual and scientific beliefs," Eda Kristin explained. They lived in New York and later Washington D.C.

"Did your family have any normal pets like cats or dogs?" I asked. "No, never!" Eda laughed. Just scorpions, seahorses, and Venus flytraps. Eda Kristin recalled an exciting childhood. She was never teased about gracing the photographs of National Geographic and teachers always excused her and her brother from school to join their parents on various expeditions and trips.

She had happy memories of how photos for the magazine were chosen. The family would gather in their darkened living room and go through hundreds of slides her father took, choosing three possible shots for each photo planned in every article. Mr. Zahl would then consult with his editors in choosing the final photos.

"But it was my mother who was his full partner. She edited all of his work, including the photography."

The Zahl children went in two opposite directions as they grew up.

Eda's brother, Paul F. M. Zahl, was valedictorian of his class at St. Alban's school, an elementary through high all-boys school popular among Washington's political families. (Al Gore and many other recognizable names went there.) In high school he found his calling. He graduated from Harvard, then attended the Harvard Divinity School, and became an Episcopal minister.

And a famous one at that. Paul Jr., highly respected and at times rather controversial for his more conservative leanings in an otherwise liberal denomination, has written or co-authored many books,

most dealing with church history and politics, as well as inspirational. Among his best known are "Five Women of the English Reformation", "The First Christian: Universal Truth in the Teachings of Jesus", and "Grace in Practice: A Theology of Everyday Life." He is married and has three sons.

On the other hand, this is the opening line of Eda Kristin's first novel called *Fluffy Butch:* "Mary learned to love men when she started dating women."

Eda Kristin went to Bennington College in Vermont and majored in literature. She moved to New York and had a successful acting career during the 1970s, co-starring with famous actors like Jason Robards and Maureen Stapleton in plays by Clifford Odets and Neil Simon. She moved to Los Angeles, a city she loves, and had guest roles on TV shows like "Roseanne", "Dallas", "Knot's Landing", and "Eight Is Enough". For several years Eda also worked for a production company that made movies like "Hoosiers".

That first novel, *Fluffy Butch,* was published in England in 1994 and got good reviews and was popular, but wasn't released in the U.S. Eda has returned to writing in recent years. She has one book circulating among agents, "about murder! But it's not a murder mystery", and is at work on third. It's also been suggested to her that she write a biography about her father and family. She lives in Los Angeles with her partner Jack Favere.

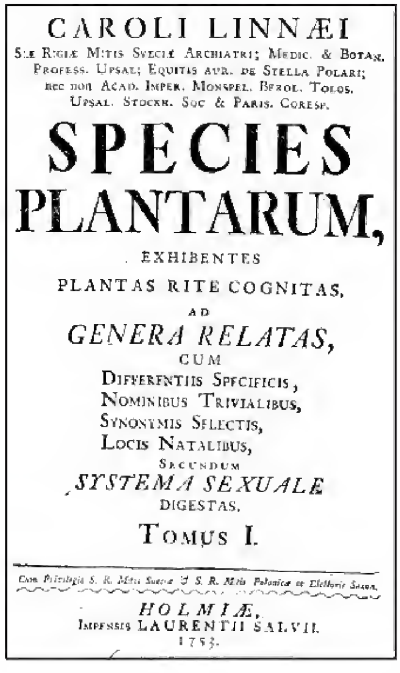
I asked Eda if she thought her father had any regrets in his very successful life. Without hesitation she said, "Cancer. He wanted to find the cure for cancer."

In a sad irony, Paul A. Zahl passed away of prostate cancer in 1985, at the age of 75. At the National Geographic Society headquarters, they hung the flag at half mast.

Web Wanderings – Botanicus (www.botanicus.org) and the *Species Plantarum*

Mike Baldwin • mike@carnivorousplants.org

Are you like me? Have you ever been curious about those early carnivorous plant citations, and maybe even wanted to look at the original source? I mean the EARLY ones? Well, now you can from the comfort of your own home. In my Web Wandering I came across a great find, Botanicus; a free to access web-based digital library of historical botanical literature scanned from the Missouri Botanical Garden Library.


CAROLI LINNÆI
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SPECIES PLANTARUM,

EXHIBENTES
PLANTAS RITE COGNITAS,
AD
GENERA RELATAS,
CUM
DIFFERENTIIS SPECIFICIS,
NOMINIBUS TRIVIALIBUS,
SYNONYMIS SELECTIS,
LOCIS NATALIBUS,
SECUNDUM
SYSTEMA SEXUALE
DIGESTAS.

TOMUS I.

Cum Privilegio S. R. Mitis Suecie & S. R. Mitis Polonica et Electoris Saxon.

HOLMIÆ,
IMPENSIS LAURENTII SALVII.
1753.

I haven't explored the full depth of Botanicus yet, but I did find *Species Plantarum* by Carl Linnaeus the father of modern taxonomy and plant nomenclature! So, when you see "*D. rotundifolia L. 1753*" in a text somewhere, now you can look at the original citation.

Published in 1753, the *Species Plantarum*, in two volumes, lists over 7,000 species including *Aldrovandra vesiculosa, Drosera* (*D. capensis, D. indica, D. rotundifolia*), *Nepenthes distillatoria, Pinguicula* (*P. alpina, P. lusitanica, P. villosa, P. vulgaris*), *Sarracenia* (*S. flava, S. purpurea*), *and Utricularia* (*U. bifida, U. caerulea, U. foliosa, U. gibba, U. minor, U. subulata, U. vulgaris).*

Have fun and go check out Botanicus!

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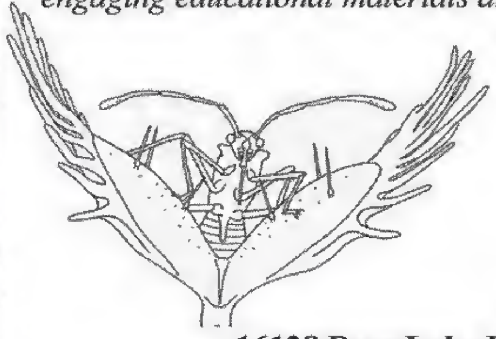

- Carnivorous Plants
- Bog Orchids, Bog Plants
- Activity Book for Carnivorous Plants
- Bugs in the Bog Board Game
- Free Monthly Drawing
- OnLine Shopping and Mail Order

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